

## SEARCHING FOR HIGH REDSHIFT CLUSTERS

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## RESUMEN

Los cúmulos de galaxias lejanos nos permiten estudiar la formación y la evolución de las galaxias y de la estructura del Universo a gran escala. Sin embargo, el número conocido de cúmulos con alto corrimiento al rojo ( $z > 0.5$ ) es muy reducido. Como preparación para estudios detallados con GTC, estamos tratando de localizar un número suficiente de estos cúmulos a alto  $z$  en cartografiados de gran campo en bandas ópticas, que complementaremos con observaciones en el infrarrojo cercano con telescopios de 4 m. Aquí presentamos algunos resultados preliminares. En un campo de  $35 \times 35$  minutos de arco cuadrados hemos detectado 8 cúmulos de galaxias con  $z > 0.5$ .

## ABSTRACT

Distant clusters of galaxies provide a powerful method to study the formation and evolution of galaxies, and large scale structure of the Universe. However, the number of known clusters at high redshift ( $z > 0.5$ ) is still very reduced. As a preparatory work for detailed studies with GTC, we are searching for high redshift clusters in public wide optical surveys. We will complement this with near IR observations in 4 m telescopes. Here, we present some preliminary results. In a field of  $35 \times 35$  arcmin<sup>2</sup> we have detected 8 clusters of galaxies at redshift  $z > 0.5$ .

**Key Words:** CLUSTERS OF GALAXIES — GALAXY EVOLUTION — GALAXY FORMATION — COSMOLOGY

## 1. INTRODUCTION

The study of high redshift clusters ( $z > 0.5$ ) is an important tool to understand both galaxy and cluster formation and evolution. For instance its number and distribution in mass and redshift allow to discriminate between different cosmological scenarios. Fig. 1 presents the expected density of clusters for a standard cosmological lambda cold dark matter model. Although the number of known high redshift clusters has increased in the last years, this number is still reduced and makes difficult statistical studies. The detection of representative numbers ( $\sim 50-100$ ) of such clusters would require the analysis of deep images covering several square degrees. Appropriate surveys in the optical exist now and will be available in the near future at near infrared wavelengths. In this contribution, we summarize our work in this area, and presents the analysis of a region of the sky  $35 \times 35$  arcmin<sup>2</sup> in several optical filters in which we have detected 8 candidates to be clusters of galaxies at  $z > 0.5$ . Additional details are given in [2]

## 2. DATA

We are analyzing the NOAO Deep Survey [3] and the Deep Lens Survey [4]. The NOAO Deep Survey

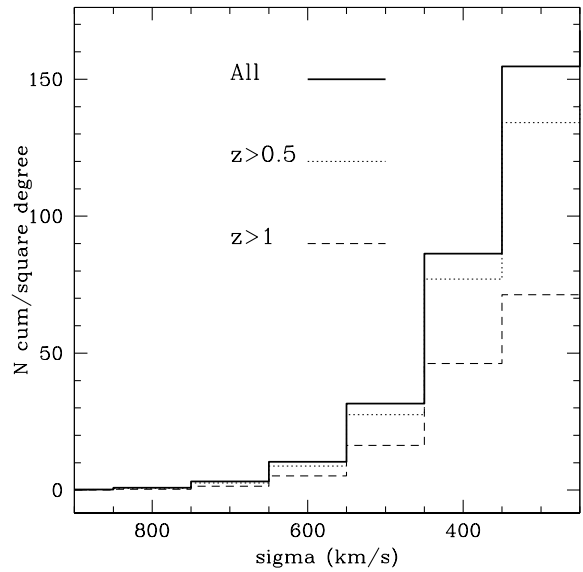


Fig. 1. Expected density of clusters and galaxy groups as a function of the velocity dispersion (or equivalently mass). The diagrams are based on simulations by the Virgo Consortium [1] assuming a flat model with  $\Omega_{CDM} = 0.3$  and  $\Omega_{\Lambda} = 0.7$ .

covers an area of 18 square degrees in the  $B_w$ ,  $R$ ,  $I$ ,  $J$ ,  $H$ ,  $K$  filters with  $5\sigma$  limiting magnitude  $R \sim 25$

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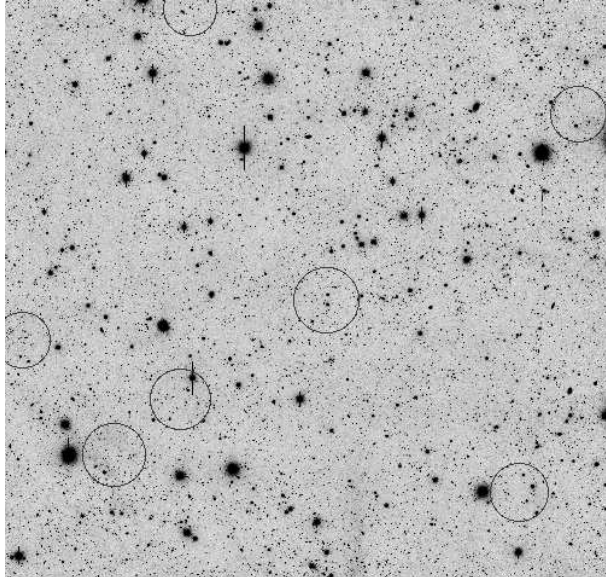


Fig. 2. Deep Lens Survey image in the R filter covering an area of  $35 \times 35$  arcmin. The circles enclosed the position where cluster candidates at  $z > 0.5$  have been found.

mag. So far, 1 square degree in the optical have been released. The Deep Lens Survey has an area of 27 square degrees (6 of them are public now), in the  $B$ ,  $V$ ,  $R$  and  $z'$  filters (some fields have been observed also in the  $I$  band). The limiting magnitude is  $R \sim 26.5$  mag.

### 3. ANALYSIS AND RESULTS

The results presented here have been obtained determining the photometric redshifts [5] and looking for overdensities in the  $(RA, Dec., redshift)$  space. So far, we have analyzed a region of  $35 \times 35$  arcmin<sup>2</sup> in which we have found several likely candidates to be high redshift clusters. Fig. 2 shows the field analyzed and the positions of the cluster candidates at  $z > 0.5$ . A list with the estimated redshifts, number of members detected and the significance of each cluster candidate is presented in Table 1. The color-magnitude ( $V - I$  vs.  $I$ ) diagram and the distribution in redshift in one of the regions in which a cluster candidate is present are shown in Figs. 3 and 4 respectively.

### REFERENCES

- [1] <http://www.mpagarching.mpg.de/Virgo/>
- [2] Gutiérrez, C. M., & Juncosa, R. 2004 (this volume)
- [3] <http://www.noao.edu/noao/noaodeep/>
- [4] <http://dls.bell-labs.com/>
- [5] Fernández-Soto, A., Lanzetta, k., & Yahil, A. 1999, ApJ, 513, 34

TABLE 1  
CLUSTER CANDIDATES AT  $Z > 0.5$

Redshift	Num. obj. zone	Reliability
0.90	6	$> 0.99$
0.85	5	0.98
0.55	6	0.90
0.60	5	0.86
0.80	4	0.82
1.50	3	0.82
1.40	3	0.80

Table 1. Candidates to be clusters of galaxies at redshift  $> 0.5$  in one of the fields of the Deep Lens Survey.

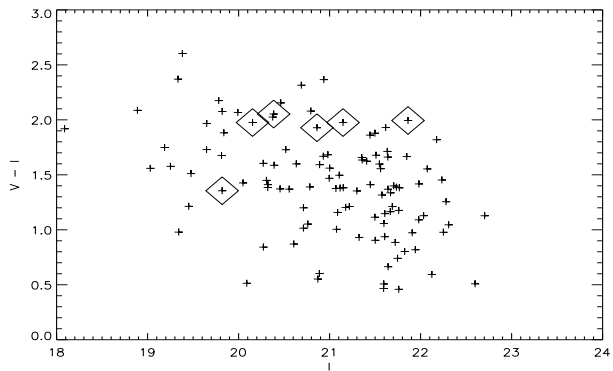


Fig. 3. Color-magnitude diagram of all the galaxies (crosses) enclosed in one of the circles shown in Figure 2; objects identified as cluster members galaxies (diamonds) follow a tight  $V - I$  vs.  $I$  relation.

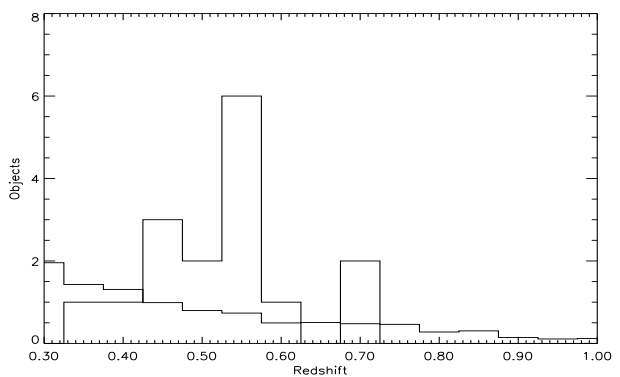


Fig. 4. The figure shows as a function of redshift: (dotted) the mean number of objects in a region of  $2 \times 2$  arcmin<sup>2</sup> of the Deep Lens Survey field shown in Fig. 2. (Dashed) the expected  $1\sigma$  upper limit for a random *Poisson* distribution, and (solid) the actual distribution of objects in such region. A clear overdensity exists at  $z \sim 0.6$ .

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